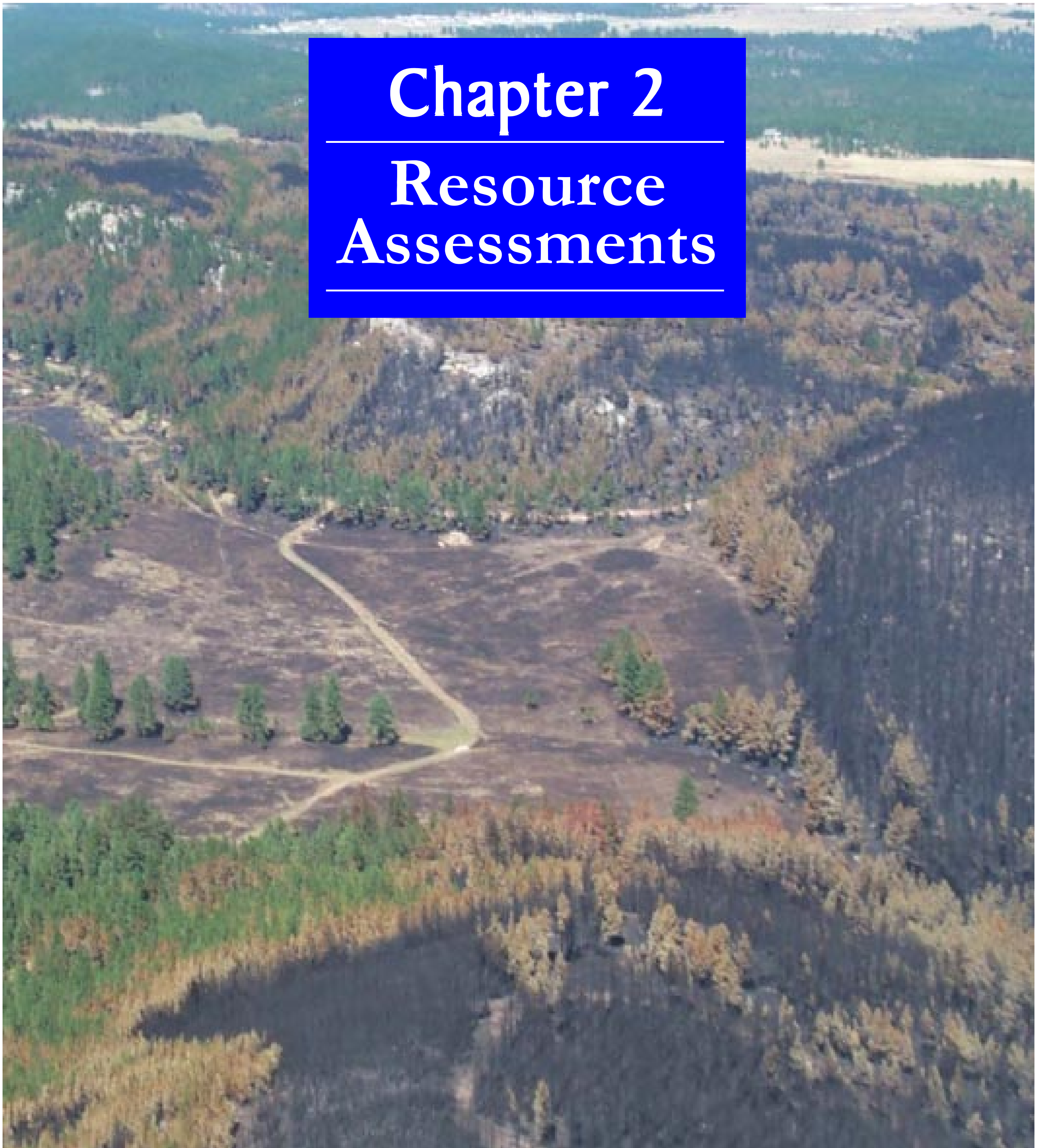
Chapter 2

Resource Assessments



WATERSHED

Pre-fire Conditions

Precipitation and Climate

Battle Creek Fire area elevations range from 3,800 feet near Hayward to over 5,400 feet on Silver Mountain. The Battle Creek Fire area has a semi-arid climate with low humidity throughout the year. Temperatures range from 100° F during summer months to well below 0° F in winter. Average annual precipitation for the area is 19 inches and generally decreases from west to east. Approximately 50% of the annual precipitation occurs May through July and approximately 75% of the annual precipitation occurs April through August. Localized intense thunder cells associated with the monsoons can produce much greater rain than surrounding areas within one storm event. The largest recorded storm in the Black Hills occurred on June 9, 1972. About 10 to 15 inches of rain fell on the central Hills, resulting in the devastating flood of Rapid City that killed over 200 people.

The Battle Creek Fire area is surrounded by weather stations. In the table below are the stations in the area with their averages. The table displays the 30-year average from 1961 to 1990. Rapid City is located 11 miles northeast, Hermosa is 12 miles southeast, Mt. Rushmore is 4 miles southwest and Hill City is 10 miles east.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Annual
Rapid City	0.33	0.49	0.95	2.08	3.18	3.30	2.58	2.01	1.23	1.10	0.48	0.42	18.15
Hermosa	0.27	0.40	0.81	1.78	2.97	3.07	2.63	1.47	1.25	0.94	0.44	0.39	16.42
Mt. Rushmore	0.33	0.52	1.03	2.09	3.68	4.08	3.36	1.88	1.61	0.98	0.55	0.50	20.61
Hill City	0.28	0.54	0.92	2.13	3.30	3.73	3.49	2.05	1.51	0.98	0.58	0.47	19.98
Average	0.30	0.49	0.93	2.02	3.29	3.54	3.01	1.85	1.40	1.00	0.52	0.44	18.79

Streamflow

Streamflow within the Battle Creek Area is different from the east side to the west side of the fire, due to differences in geology. The east side generally does not see flows in the channels except from an intense precipitation event. The channels are generally ephemeral. The west side streams are more intermittent and perennial channels and see more frequent and persistent flows.

Water Quantity and Peak Flow

In reviewing the USGS data along Battle Creek at stations near Keystone and Hermosa, peak flows have occurred in any month from March through October. Most of the peaks occur during the months May, June or July with the most occurring in June. These peaks fall right in line with the precipitation averages and are related to precipitation events.

Water Quality
Battle Creek near Hayward is designated as an impaired water body in the 1998 State of South Dakota 305(b) report. The pollutants of concern are pH, temperature, and ammonia and the priority for development of a Total Maximum Daily Load is high. The sources of these pollutants are not listed, but municipal and residential developments in the canyon bottoms are likely candidates.

Wetlands
Mapped wetlands are scattered throughout the Battle Creek Fire area. They are primarily linear wetlands along stream channels or associated with seeps and springs.

Floodplains
Mapped FEMA floodplains within the Battle Creek Fire are along Battle Creek. None of the other streams within the fire area are mapped. Mapped floodplains downstream from the fire area include Deadman Gulch and Battle Creek in the Battle Creek Watershed and Rockerville Gulch and Spring Creek in the Spring Creek Watershed.

Watersheds
The Battle Creek Fire is within three HUC 6 watersheds, Upper Battle Creek, Lower Battle Creek and Lower Spring Creek. HUC 6 watersheds are generally 10,000 to 50,000 acres in size. Within those HUC 6 watersheds, the fire affected six HUC 7 watersheds. HUC 7 watersheds are generally 5,000 to 10,000 acres in size. All watersheds are tributaries to the Cheyenne River.

Post-fire Conditions

Streamflow
Changes to the streamflow and stream channels are expected to occur. The east side of the fire stream channels will more than likely see a change from ephemeral to intermittent channels and see more frequent flows until the ground cover over the area recovers. The west side will see more persistent flows as a result of more water available for stream flow. Due to the decrease in vegetation, there may be an increase of water in the caves.

Water Quantity and Peak Flow
The table below illustrates what increase in peak flow can be expected as a result of the Battle Creek Fire. Two year return interval storms are illustrated here and data for other return interval storms are available in the BAER report and analysis.

Watershed Name	Acres	Pre-Fire 2-Year Return Interval Flood cfs	Post-Fire 2-Year Return Interval Flood cfs
Battle Creek	25184	275	2196
Tepee Gulch	3738	41	448
Bobtail Gulch	1120	53	582
Keystone Dump	198	2	7
Horsely Gulch	262	3	20
Foster Gulch	4282	47	1121
Johnson Gulch	2758	30	120
Rockerville Gulch	800	9	87
Cabin Creek	1024	11	56
North Deadman Tributary in section 32	627	8	191
South Deadman Tributary in section 32	1331	15	378
Deadman Tributary in section 5	422	5	202
Deadman Tributary near Jackson Spring	589	6	275
Lost Cave & Dog House Gulch	1146	13	350

Water Quality
There is potential for post-fire stormflow to contribute ash and eroded soil to the stream channel, which could increase pH and ammonia. However, the remaining and newly establishing vegetation will quickly capture most nutrients made available as a result of the fire. Temperature should not be impacted given that the fire only affected intermittent and ephemeral channels in Battle Creek drainage.

Wetlands
Wetlands will be impacted by the increased flows as a result of the fire. Ash and sediment will be deposited in these areas. The impact will be short term and should be beneficial as this is a process that has occurred long before the area was settled and developed.

Floodplains

The mapped FEMA floodplains should not see a significant increase in flows from the Battle Creek Fire area. There will be increased flows in these areas but the drainage area and floodplains are such that it should be able to absorb the flows with out much of an increase in flood elevations.

The significant increases are going to occur on the unmapped floodplains. Any drainage in the fire area and immediately downstream will carry water and the increases are projected to be significant. See the section on Water Quantity and Peak Flows for more details.

Watersheds

The Battle Creek fire covered a significant area. It included parts of three HUC 6 watershed, as shown below.

HUC 6 Watershed Name	HUC 6 Watershed Number	Watershed Acres	Acres of Watershed within Fire	% Of Watershed within Fire
Upper Battle Creek	101201090501	37,321	2,903	8%
Lower Battle Creek	101201090502	29,546	8,193	38%
Lower Spring Creek	101201090604	27,195	1,355	5%

Upper Battle Creek and Lower Spring Creek watersheds had only a small portion of the Battle Creek Fire within them. Lower Battle Creek had a large portion of the watershed within the fire perimeter. Each HUC 6 watershed will be discussed separately below and will also be broken down into HUC 7 watersheds.

Upper Battle Creek HUC 6 – This is a headwaters watershed. A headwaters watershed is the beginning of a watershed and does not have any water flowing into it other than rainfall or spring flow and all of the water flowing out of the watershed was generated within the watershed. The portion of the Upper Battle Creek watershed within the fire perimeter is small, 8%, is in the northeastern part of the watershed.

This watershed is broken down into six HUC 7 watersheds, as shown in the table below.

HUC 7 Watershed Name	HUC 7 Watershed Number	Watershed Acres	Acres of Watershed within Fire	% Of Watershed within Fire
Upper Battle Creek	10120109050101	9,238	0	0%
Grizzly Bear Creek	10120109050102	6,641	0	0%
Tepee Gulch	10120109050103	4,977	2,082	42%
Middle Battle Creek	10120109050104	4,319	821	19%
Upper Iron Creek	10120109050105	5,733	0	0%
Lower Iron Creek	10120109050106	6,413	0	0%

The Battle Creek Fire affected two of the HUC 7 watersheds. The fire intensity is indicated in the table below.

HUC 7 Watershed Name	Fire Intensity							
	High		Moderate		Low or Unburned		Outside Fire Perimeter	
	Acres	%	Acres	%	Acres	%	Acres	%
Tepee Gulch	499	10%	377	8%	1,207	24%	2,895	58%
Middle Battle Creek	81	2%	147	3%	593	14%	3,498	81%

Lower Battle Creek HUC 6 – This watershed is a mid basin watershed. A mid basin watershed is a watershed that has water from another watershed flowing into this watershed and flowing out with the water generated by this watershed. Upper Battle Creek HUC 6 watershed flows into this watershed. A large percentage of this watershed is within the fire perimeter, 38%, and is the most impacted of the three HUC 6 watersheds.

This watershed is broken down into four HUC 7 watersheds. See table below.

HUC 7 Watershed Name	HUC 7 Watershed Number	Watershed Acres	Acres of Watershed within Fire	% Of Watershed within Fire
Foster Gulch	10120109050201	7,809	4,393	56%
Lakota Peak	10120109050202	6,544	2	0%
Deadman Gulch	10120109050203	6,357	3,798	60%
Lower Battle Creek	10120109050204	8,836	13	0%

The Battle Creek Fire affected two of the HUC 7 watersheds. See table below for fire intensities within the HUC 7 watersheds.

HUC 7 Watershed Name	Fire Intensity							
	High		Moderate		Low or Unburned		Outside Fire Perimeter	
	Acres	%	Acres	%	Acres	%	Acres	%
Foster Gulch	1,117	14%	1,279	16%	1,997	26%	3,416	44%
Deadman Gulch	1,062	17%	1,222	19%	1,514	24%	2,559	40%

Lower Spring Creek HUC 6 – This watershed is a mid basin watershed. Above this watershed are Upper Spring Creek, Newton Fork, and Sheridan Lake HUC 6 watersheds, which flow into this watershed. A small portion of the Lower Spring Creek watershed is included in the fire perimeter, 5%. It is the southern portion where of the watershed.

This watershed is broken down into four HUC 7 watersheds. See table below.

HUC 7 Watershed Name	HUC 7 Watershed Number	Watershed Acres	Acres of Watershed within Fire	% Of Watershed within Fire
Bitter Creek	10120109060401	7,627	542	7%
Deadman Creek	10120109060402	5,157	36	1%
Lower Spring Creek	10120109060403	6,484	0	0%
Rockerville Gulch	10120109060404	7,926	777	10%

The Battle Creek Fire affected two of the HUC 7 watersheds. See table below for fire intensity within the HUC7 watersheds.

HUC 7 Watershed Name	Fire Intensity							
	High		Moderate		Low or Unburned		Outside Fire Perimeter	
	Acres	%	Acres	%	Acres	%	Acres	%
Bitter Creek	38	1%	176	2%	328	4%	7,086	93%
Rockerville Gulch	58	1%	109	1%	609	8%	7,150	90%

Of the HUC 6 watersheds, Lower Battle Creek is the one most affected by the fire. Almost 40% of the area is within the fire perimeter. The other two HUC 6 watersheds, Upper Battle Creek and Lower Spring Creek, had small areas of their watersheds affected, less than 10%.

HUC 7 watersheds affected by the fire include Foster Gulch and Deadman Gulch, which have greater than 50% of their area within the fire perimeter. Tepee Gulch and Middle Battle Creek had 20 to 40% of their area within the fire perimeter. Bitter Creek and Rockerville Gulch had less than 10% within the fire.

Recommendations

Vegetative Treatment

Concerns

- Potential to increase the watershed emergency.
- Potential to retard the speed of watershed recovery.

Goals

- Not to increase the watershed emergency.
- Not to retard the speed of watershed recovery.
- Strategically improve the watershed condition.
- Strive for 60% ground cover.
- Minimize disturbance of ground cover that remained after the fire.
- Minimize concentration of runnoff.

Recommendations applicable to all areas of the fire.

- Design skid trails to minimize the concentration of runoff.
- Avoid storage or deposition of slash, log decks, and other materials within drainages.
- Avoid extensive disturbance of residual duff and litter.
- When falling trees that are to be retained on-site, fall on the contour.

High Intensity Areas

There is an opportunity to increase the ground cover by putting limbs and tops of trees on the ground.

Moderate Intensity Areas

These are the most sensitive areas within the fire area. Post-fire activities within these areas have the highest potential to change the character of these sites and move them to flood source areas.

- In moderate areas, remaining tree needles will fall this winter and be compacted by snow and rain. This will help decrease flooding potential. Disturbing these areas or removing the needle source could put the area back into a flood source area.
- Leave enough trees to achieve 60% or more ground cover after treatment is completed. A torturous water path during high-intensity storms is desired to slow the water getting to a stream channel.

Low Intensity Areas

It is recommend that enough trees be left to achieve 60% ground cover after treatment is completed if the litter and duff layer was consumed.

Range Management

Grazing should not occur until there is at least 60% ground cover on the area to be grazed. Grazing too soon will remove vegetation that would have been available for ground cover.

Road 366.1/Lower Tepee Gulch

These roads should be closed and obliterated.

- This road is in a bad location. The road follows Tepee Gulch and crosses the stream eight times. Significant sediment from the road has been deposited in Tepee Gulch at each road crossing. The stream substrate is different below the crossing from above. Below there is nothing but fines and above there is a good rocky substrate. This problem will be aggravated and made worse because of the fire.
- If the road is closed, it should be obliterated at the sections where it crosses and is near the stream. The stream banks will need to be rebuilt. The stream channel will need to be cleaned out below several crossings.
- If the road remains open, stream crossings should be improved with concrete mats. This will not be cheap as the stream and road do not cross at right angles and more mats will be needed to stabilize the stream and the banks. Gravel will also be needed on the approaches. The stream channel will need to be cleaned out below several crossings.

Road 366.2/Upper Tepee Gulch

Road crossings should be improved.

- This is a good gravel road with three road and stream crossings. The crossings were improved by placing gravel at the crossing. This works for a short period of time, but does not hold up to the continual traffic. The crossings widen with time, sediment is transported down stream, and the gravel also migrates downstream. Also, there are no drainage structures to keep the water from running down the road to the stream at the crossing.
- These crossings should be improved with concrete mats and rolling dips which will mitigate the road impacts to the stream.

60% Ground Cover Discussion

Howard K. Orr did a study following the 1959 Deadwood Fire. His conclusion is that 60% ground-cover density (live vegetation plus litter) is postulated as the minimum necessary for soil stabilization. Overland runoff and soil erosion showed a progressive deceleration as total ground cover increased to 60%. Further increase in ground cover over 60%, runoff and sediment production declined at a slower rate.

Evaluation & Monitoring

- Develop contracts with provisions that address the concerns, goals and actions of this report.
- The District Hydrologist should be consulted as needed when questions arise.
- Normal BMP monitoring will take place.
- Rain gages will be located across the fire area to gather data for the smaller isolated storms.

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SOILS

Pre-fire Conditions

Geology/Physiography

Most of the burned area within the Battle Creek Fire is characterized by the mountainous topography of the Black Hills, with many areas containing steep slopes and narrow canyon bottoms (See Figure 1). The eastern third of the fire area is located in the steeply dipping plateau lands of the Deadwood, Minnelusa, and Madison Limestone and Englewood Formations. The western two-thirds are situated in the central crystalline area, comprised primarily of greywacke with lesser amounts of metamorphosed sedimentary rock outcroppings. Slopes range from nearly flat on the plateau-like ridge tops and grassy meadows to greater than 80% on the steep eastern slopes and canyon walls. Elevations of the burned area range from approximately 3650 feet in the southernmost tip of the fire to 5400 feet at the summit of Silver Mountain in the northwestern portion of the fire.

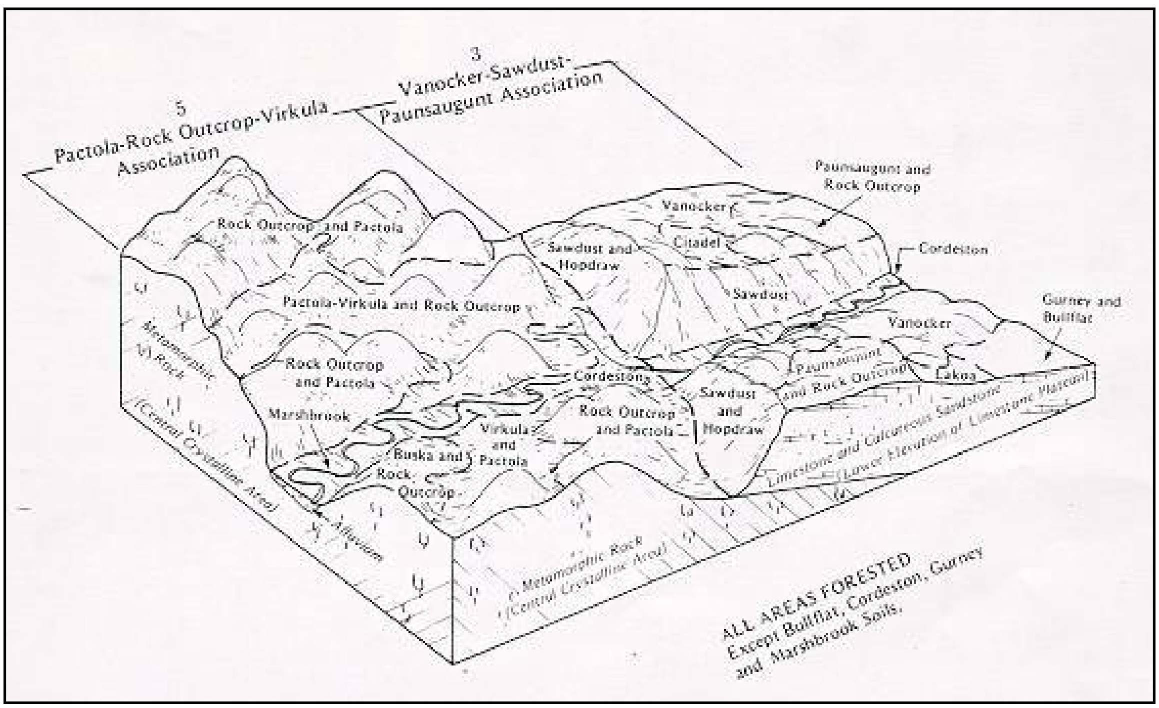


Figure 1. Cross-Section of Geology, Physiography, and Soils

Soils

The dominant soils within the fire perimeter are comprised of various complexes in combinations of the following soil types: Pactola, Virkula, Vanocker, Citadel, Sawdust, Buska, Paunsaugunt, Gurney, Hopdraw, Lakoa and rock outcroppings. These generally fall within two major associations – the Vanocker-Sawdust-Paunsaugunt and the Pactola-Rock Outcrop-Virkula. Small units of Barnum, Bullflat, Cordeston, Columbo, Marshbrook, Winetti, Heeley, and Hilger soils are also found within the burned area. These lesser soil types are generally managed as grazing areas.

The Vanocker-Sawdust-Paunsaugunt association consists of deep and shallow, well drained, gently sloping to very steep, loamy soils formed from weathered limestone and calcareous sandstone. It is located on mountains at the lower elevations of the Limestone Plateau. It is characterized by broad ridges and canyons, and is highly dissected by drainage ways and major streams. Some canyons are deeply entrenched and have very steep side slopes and rimrock ledges. Minor soil types in this association include Bullflat, Citadel, Cordeston, Gurney, Hopdraw and Lakoa, as well as areas of Rock outcrop. The deep Bullflat, Citadel, Cordeston, and Lakoa soils have fewer coarse fragments than the major soils. Bullflat, Citadel, Gurney, and Lakoa soils are on the less sloping parts of the landscape, with Cordeston soils found along drainage ways. The deep, sandy Hopdraw soils occur in scattered areas throughout the association. Gurney soils have bedrock at a depth of about 28 inches. The rock outcroppings occur as ledges and ridges of limestone and sandstone. Nearly all of this association is managed for Ponderosa Pine production, with most areas also used for livestock grazing.

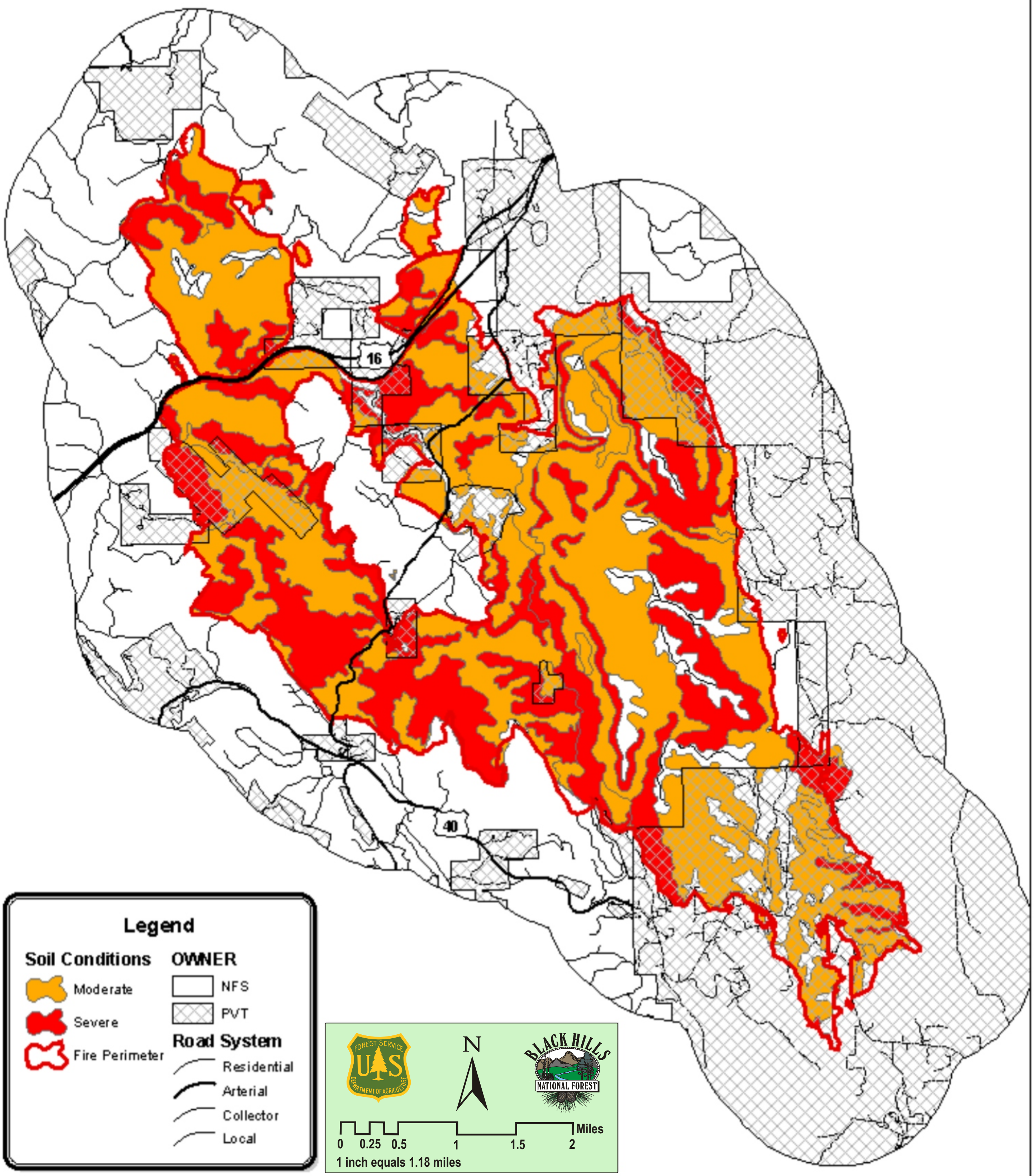
Soil in a high severity burn area

The Pactola-Rock Outcrop-Virkula Association consists of Rock outcrop and deep, well drained, gently sloping to very steep, loamy soils formed in material weathered from steeply tilted metamorphic rock. It is located on mountains in the Central Crystalline area. Ridges, peaks, and canyons characterize this association. It is highly dissected by drainage ways and major streams, which are deeply entrenched. The Rock outcrop consists of peaks, ledges, and dikes of extremely hard, highly fractured, steeply tilted metamorphic rock. The Virkula soils are on the slightly concave, mid and low side slopes. Minor soils in this association are the Buska and Cordeston soils and the poorly drained Marshbrook soils. Buska soils formed in material weathered from micaceous schist. They are in landscape positions similar to those of the Pactola soils. Cordeston and Marshbrook soils formed in alluvium and are along drainage ways. Nearly all of this association is forested, with small areas used for range.

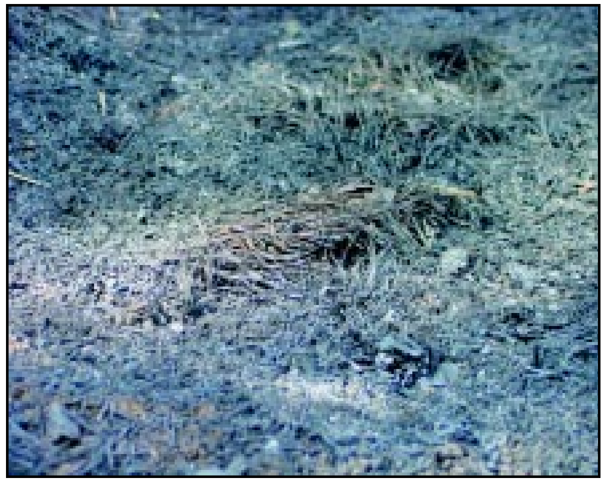
Within the fire, 4,149 acres (33% of the fire area) consist of the Hopdraw-Sawdust-Rock Outcrop (HtG), Rock Outcrop-Buska (RgG), Rock Outcrop-Pactola (RlG), and Rock Outcrop-Sawdust (RnG) complexes. These soils are naturally susceptible to mass movement and have a severe erosion hazard because they rapidly shed rainfall. An additional 6,995 acres or 56% of the area are comprised of soils with a moderate erosion hazard. Of these moderate erosion soils, soil units BuE, PaE, VcE, and VkE, comprising 5,919 acres, also have the potential for mass movement on steep and disturbed areas. (*See map on next page*)

Testing soil hydrophobicity

Soils with Moderate or Severe Erosion Hazards



Post-fire Conditions



Duff layer in moderate severity burn

Soil Productivity

Soil productivity is the inherent capacity of a soil to support the growth of specified plants, plant communities, or a sequence of plant communities. Following the Battle Creek Fire, a Burned Area Emergency Rehabilitation (BAER) team determined that the fire did not result in an emergency regarding potential loss of soil productivity. Viable plant roots were found at relatively shallow depths throughout most of the burned area. In addition, most of the duff layer and litter cover was retained in low severity areas, which comprises 6,825 acres or 55% of the fire. These areas are expected to recover quickly and should begin to revegetate during the next growing season following the fire, and as such the BAER team did not identify a need for soil productivity rehabilitation (i.e. reseeding).

Soil Cover

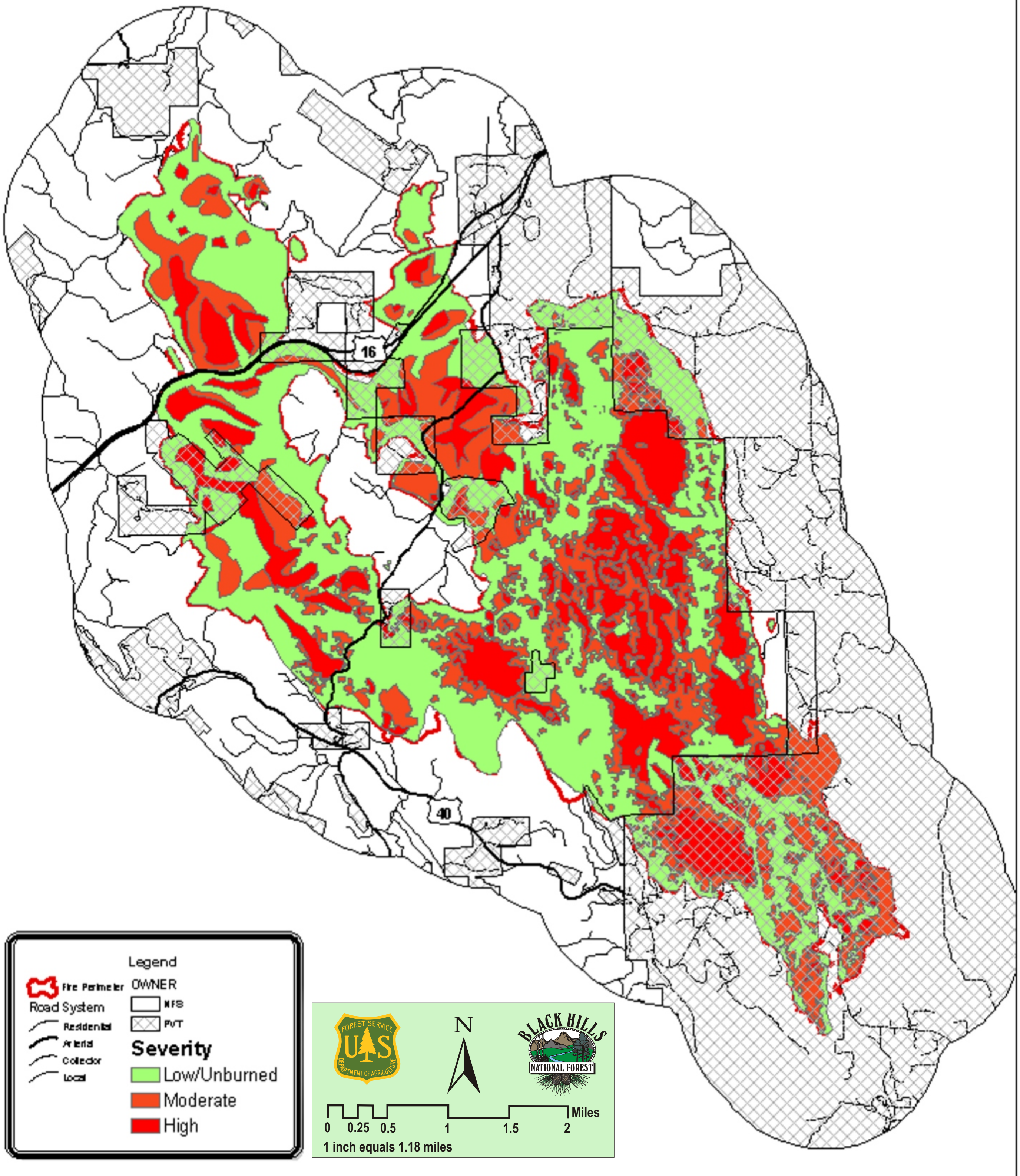
Field analyses conducted during the BAER assessment indicated that soil cover was affected. Sites classified as high severity on average had 92% bare soil conditions (surface rock, bare mineral soil, and litter with no remaining duff); under moderate severity, 65% of the site exhibited bare ground; and low and unburned severity, had 22% bare ground (*See Burn Severity Map*).

Following a wildfire, one of the most important variables in reducing overland flow is the duff layer. Duff acts as a natural sponge, temporarily storing rainfall, allowing it to infiltrate slowly, and thus reducing erosion. Sod-like duff layers also serve as a soil stabilizing mechanism. In areas classified as low severity, most of the duff layer and litter cover were retained. In moderate severity areas, a duff layer was present, however it was found in thin, discontinuous patches. Generally, in the high severity areas, pre-fire litter cover and duff were entirely consumed, leaving 2-3" thick ash layers where the litter and duff once were. Where a duff layer is still present, it is typically not more than ¼" thick.

In light of these conditions, measures will need to be taken before ground-disturbing activities resume, in order to:

- Retain the existing productivity of burned sites, and
- Retard soil loss due to erosion by removal of stabilizing root systems associated with dead-standing timber or disturbance of remaining litter and duff.

Battle Creek
Fire Severity



Erosion Hazard

Erosion is a natural process occurring on the landscape. The rate and scale of erosion in the Black Hills depends on local geology, topography, vegetation, and climate. Fires and fire management activities also have the potential to increase the amount of material transported offsite, as well as accelerate the rate at which it is removed. Removal of topsoil, along with the associated organic matter, through the forces of erosion or by mechanical disturbance, can result in a decrease in site productivity.

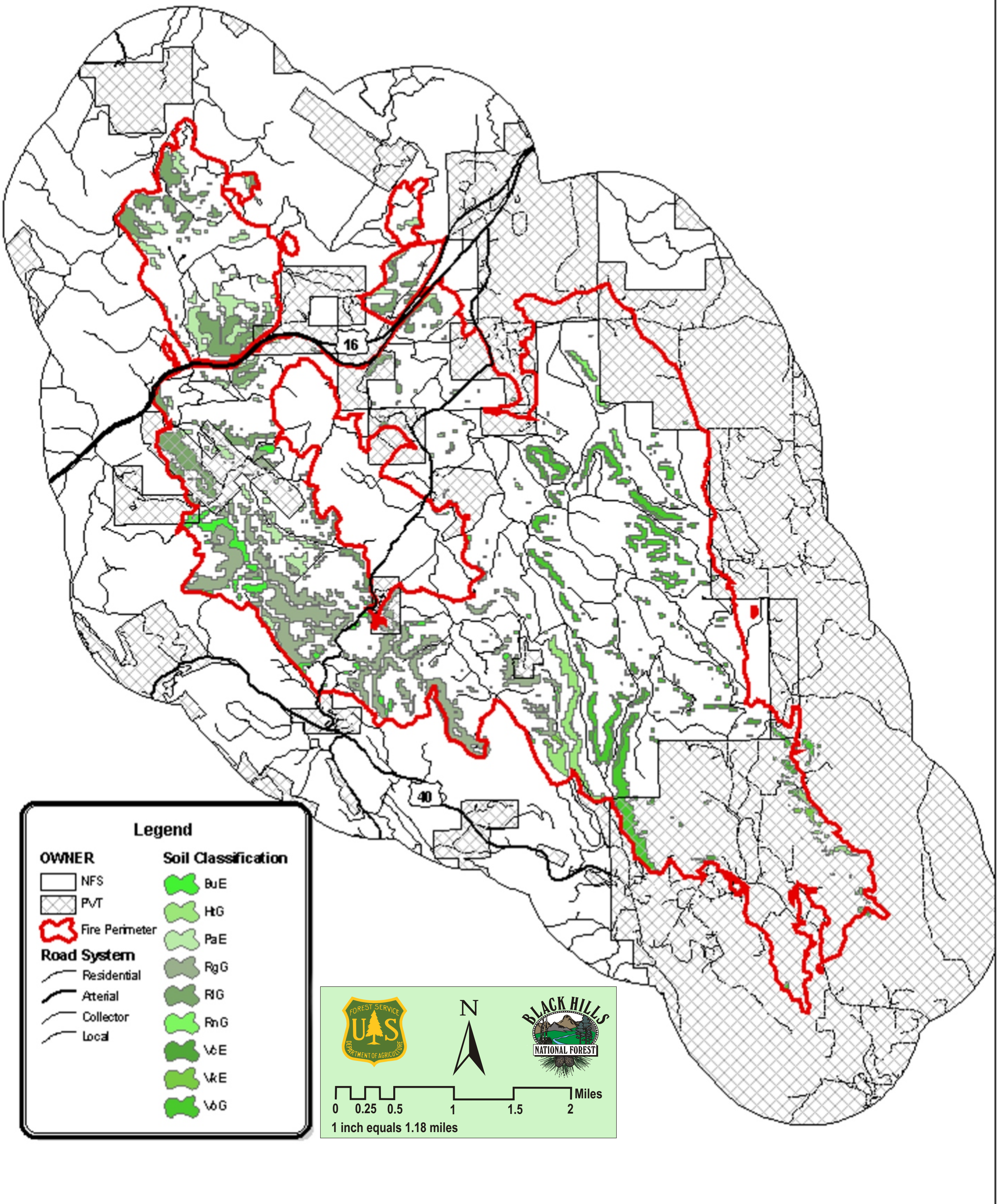
Each soil is assigned an erosion hazard rating based on soil characteristics and slope (*See Erosion Hazard Map*). Erosion hazard is the soil's relative susceptibility to sheet and rill erosion when the surface vegetative cover is completely removed from the site. Ground cover requirements to prevent soil erosion from exceeding tolerance limits were calculated with the Universal Soil Loss Equation (USLE) for soil types within the fire perimeter and can be found in the Custer and Pennington County Soil Inventory Notebook (prepared by Darwin Hoeft, Black Hills NF Soil Scientist, retired).

Dozer line

Orr (1970) examined plant cover and erosion for 3 years following the 1959 Deadwood Fire in the northern Black Hills. Extensive areas of the 4,500-acre burn experienced complete consumption of humus down to mineral soil. The area was seeded with a mixture of grasses and legumes. Results indicated that storm runoff was 50 percent less on plots with high plant and litter cover than on those with sparse cover. Analysis showed a decrease in runoff and sediment production with increasing ground cover up to 60 percent cover. It was postulated that total ground cover must equal or exceed about 60 percent density for minimum tolerable runoff control and soil stability.

Fire suppression dozer lines are another area of erosion concern, especially on steeper slopes. Teams are already working to rehabilitate dozer lines by constructing water bars, pulling soil berms and slash back into place, and reseeding the firelines. However, vegetative crowns are usually removed during the construction of dozer lines. It will be important that these areas be given enough time for vegetation to develop adequate root masses and above ground biomass to protect against disturbances that could result in further erosion. Examples of such disturbances include cattle grazing and trampling before a litter layer has developed, and motorized traffic due to increased accessibility. Potential accessibility in the overall fire area has increased greatly. The fire removed trees and shrubs that protected soils from motorized

Soils with Mass Movement Potential on Slopes Greater than 30%



vehicle traffic. If this type of use now occurs on burned, unvegetated slopes, increased erosion could result. Roads that before the fire may have been impassible or closed, may now be used in the condition that they are in, increasing erosion and watershed problems.

Nutrient Removal

Trees, ground vegetation, litter, and duff were mostly or entirely consumed in areas of moderate and high severity, respectively. This resulted in a "quick release" of nutrients into the soil (Graham et al 1994). Fallen dead trees and root masses will continue to release a constant nutrient supply as they decay. This decaying woody debris provides nutrients necessary for new plant growth and hosts ectomycorrhizae, micro-organisms which play an important role in the uptake of nutrients and water by woody plants (Graham et al 1994). Soil surface layers contain the highest amount of nutrients in a form most readily available for plant uptake. In particular, Nitrogen is the one nutrient that is in the most demand by vegetation and is only found in the soil's surface layers. Increased erosion will result in the removal of nitrogen and other vital nutrients needed for successful establishment of vegetation.

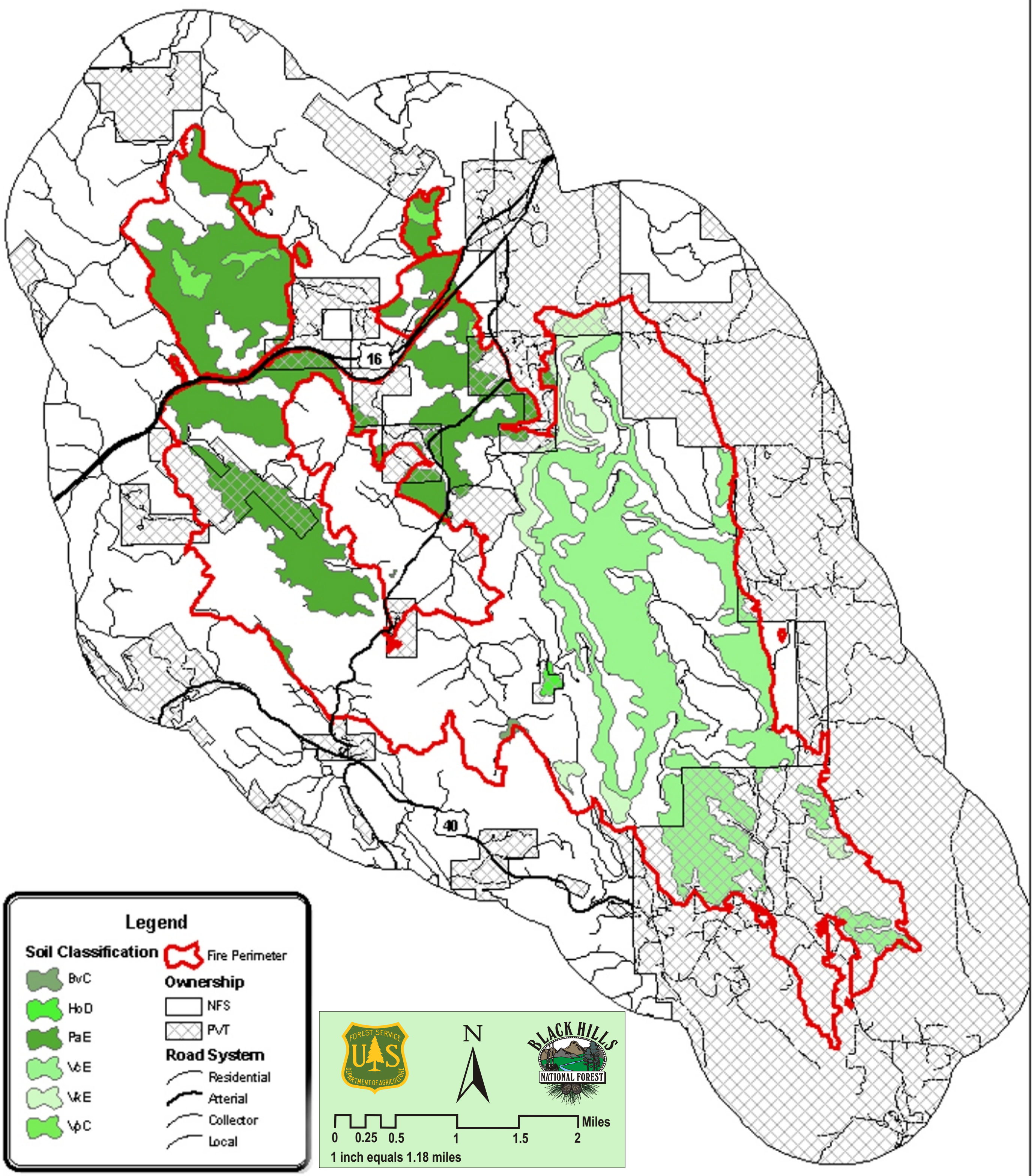
Mass Movement Potential

A significant portion of the burned area is naturally susceptible to mass movement, prior to fire disturbance, due to the large amount of surface rock and unsuitability to timber production. The potential for mass movement in these areas has now increased due to the consumption of trees, which provided slope-stabilizing root masses. Intense rainfall associated with summer thunderstorms and post-fire, ground-disturbing activities may further augment the mass movement potential. Mass movement exposes extensive areas of bare soil on hill slopes and can result in debris flows, transporting large boulders, dead trees, and sediment, effectively pulverizing anything in its path. Areas of most concern are those soil units identified as having a mass movement potential that intersect hill slopes of 25% or greater (*See Mass Movement Potential Map*).

Soil Compaction

Soil compaction is caused when excess weight is placed on the soil, as by vehicles or large animals. Compaction associated with vehicles is often accompanied by the formation of ruts, which collect and concentrate runoff, thus increasing erosion. Compaction impairs infiltration, root growth, and soil biota, increasing runoff and the associated effects of increased erosion. Soil map units BvC, HoD, PaE, VcE, VkE, and VpC within the Battle Creek fire perimeter are composed of soils that are susceptible to compaction when wet (*See Soil Compaction Potential Map*).

Soil Compaction Potential



Reforestation Potential

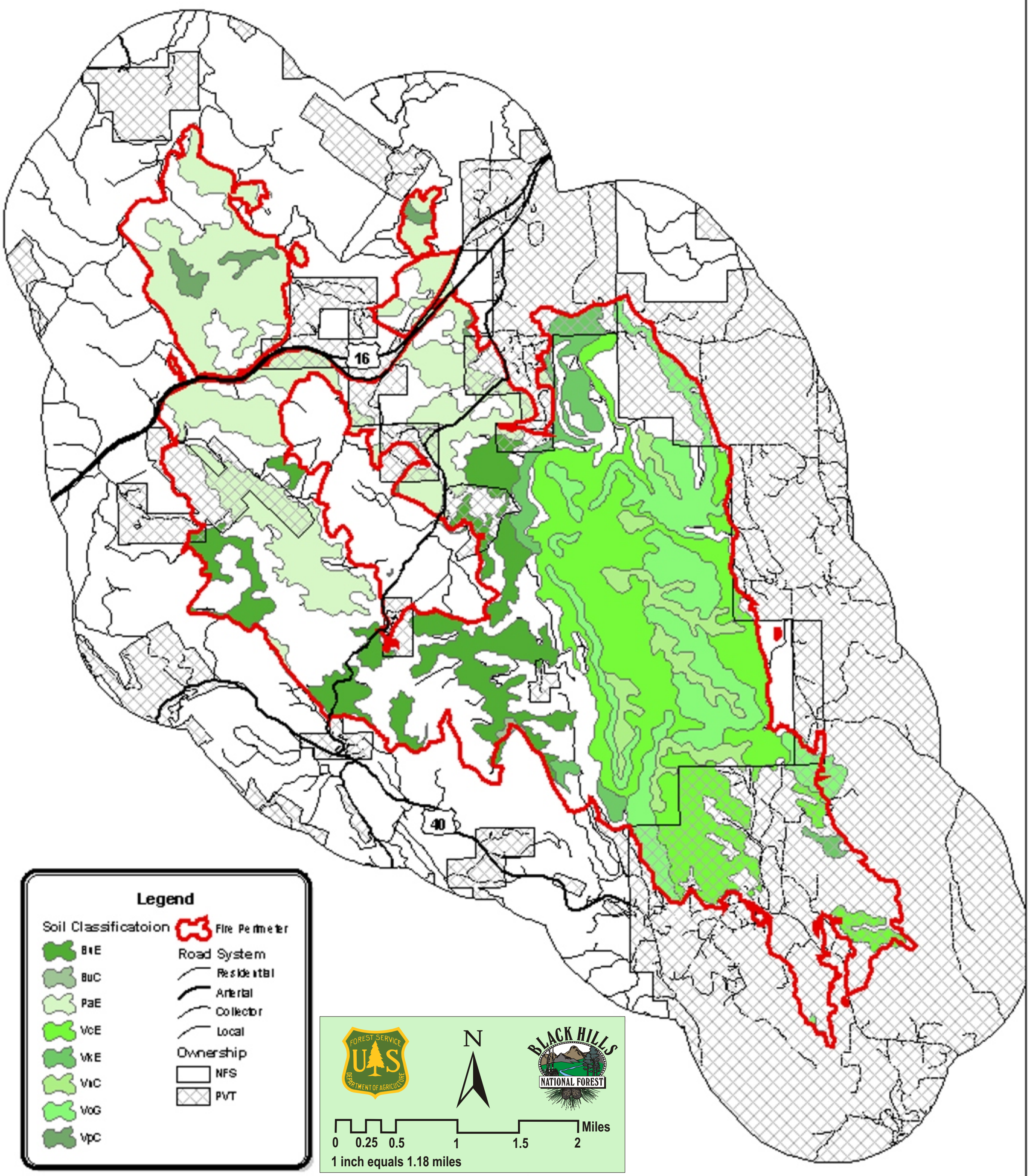
Foresters consider soil interpretations when determining land suitability. These interpretations are used to predict soil response to various activities. The ratings assume the soils are in their natural condition and do not consider current uses, accessibility, or other factors related to forest land use. The assessment team used soil interpretations to estimate the potential for successful natural tree regeneration on soil types in the fire area.

Natural tree regeneration could be impeded on some sites by seedling mortality, plant competition, and other factors. In the Black Hills, competition with other vegetation is one of the major factors that can prevent successful restocking. Some of the soil types in the Battle Creek Fire area are rated “moderate” for vegetative competition with ponderosa pine, and natural regeneration in the burned area may be hindered by this competition. Other problems include the lack of nearby seed trees in the more heavily burned areas, and the possibility of low seed production years and drought conditions. Successful regeneration will also depend on moisture retention. Soils will dry faster where the canopy, litter, and down woody debris were consumed by the fire. This increases the potential for seedling mortality. Leaving down woody debris on site would help retain soil moisture and encourage vegetation re-establishment.

Seedling mortality ratings are probably the best available prediction of hand tree planting success. Seedling mortality refers to the probability of survival of naturally occurring or planted tree seedlings, as influenced by soil type and topographic conditions. The primary causes of seedling mortality are too much water (soil wetness) or too little water (soil droughtiness). Excessive soil wetness is caused by a seasonally high water table or flooding during a substantial part of the growing season. Soil droughtiness can be caused by available water holding capacity, shallow rooting depth, or high evaporation rates. Within the fire area, the soil map units with the lowest potential for seedling mortality are include BuE, BvC, PaE, VcE, VkE, VnC, VoG, and VpC. (*See Seedling Mortality Map*) These soil units total 7,755 acres, or 62% of the fire area. VpC soils have a high available water capacity, which benefits competing vegetation as well as tree seedlings and may affect seedling establishment. The remaining soil types have low to moderate available water capacities. Planting can occur on other soil map units, but measures such as using special planting stock, bedding, planting on north-facing slopes, etc., may be needed to offset the seedling mortality hazard.

Regeneration of areas of moderate fire intensity and high fire intensity will require the retention of a certain amount of burned trees falling on the site for moisture retention and soil stabilization. Between the fire consumption of tree canopies, litter and downed woody debris, these soils will have the potential to dry faster and there is a higher potential for seedling mortality.

Soils with Lowest Seedling Mortality



Recommendations

Objectives of all recommendations are to:

- Retain soil productivity
- Minimize retarding vegetative recovery
- Minimize retarding formation of duff and litter layers
- Minimize increasing sediment transport off site (directly related to all the above and avoiding increasing overland flow)

- All potential activities should be focused on minimizing or eliminating ground disturbance on soils with mass wasting potential, steep slopes, and moderate and high burn severities.

- Soil map units BvC, HoD, PaE, VcE, VkE, and VpC within the Battle Creek fire perimeter are composed of soils that are susceptible to compaction when wet. Logging activities such as skidding and hauling can cause surface compaction and rutting, which concentrate runoff and increase erosion. These activities as well as other forms of mechanical disturbance should be restricted to periods when the soil is dry or frozen, or avoided altogether.

- In moderate and high burn severity areas, as well as areas identified as mass wasting soils (BuE, HtG, PaE, RgG, RlG, RnG, VcE, VkE, and VpC) harvesting and thinning methods that do not isolate the remaining trees or leave them widely spaced will help to overcome windthrow hazard of dead and live trees, thus providing slope stabilization. Retaining live trees, stumps, and root masses on site will also stabilize slopes and reduce sediment transport. The additional canopy cover provided by live trees, as well as the litter cover provided by needle cast from dying trees, will help to protect the ground from raindrop splash and increased erosion.

- In moderate and high severity areas, seeding, mulching, and installing water bars on skid trails and dozer lines will help stabilize and protect soils from runoff and increased erosion. Skid trails should be designed to avoid concentrating overland flow and connecting disturbed areas to existing channels.

- Installing and/or maintaining culverts and rolling dips on roads will help alleviate concentrated runoff, thus reducing erosion.

- Grazing should not occur until adequate duff and litter layers are formed and vegetation has recovered. The duff and litter should combine to provide at least 60% groundcover.

Evaluation And Monitoring

- Monitor watershed recovery and formation of ground cover to plan and adjust management activities using the quantitative grid method developed in thesis study of Post-fire Hydrologic Effects of the Jasper Fire, Gould, to be published 12/2002.

- Road crossings within and downstream of the fire will need to be identified and monitored for plugging associated with transport of ash, sediment, and debris during and after rain events.

- Monitor recovery of dozer lines.

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VEGETATION, INSECTS, AND DISEASE

Pre-fire Conditions

Tree Species Composition

The majority of the burn area is forested with ponderosa pine Approximately 6% of the area is also forested with bur oak, aspen and some minor amounts of other low elevation species such as hop hornbeam.

Age Class Distribution

Approximately 20% of the area has stands of ponderosa pine over 100 years of age. Seventy percent of the pine acres are within the 60 to 100 year range with the remaining 10% less than 60 years of age.

Stocking Levels

Generally, 50% of the pine area had high stocking levels of pine; 40% had moderate stocking levels and 10% were in low or a non-stocked condition.

Regeneration

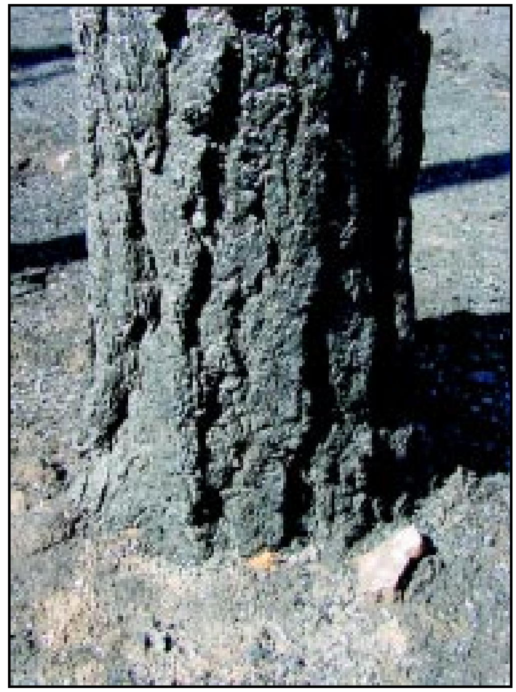
Pine regeneration within both the crystalline area (western portions of the burn), and limestone area (east) was very abundant. The most common plant association in the area is ponderosa pine/snowberry, which is associated with good pine regeneration potential. Past treatments and small burns (i.e. Jackson Springs burn) within this area has resulted in fully stocked pine stands. Older large burns such as the previous Battle Creek burn have also regenerated well with a ponderosa pine/bur oak mix.

Suitable Land Base

Within the burn area there are three major management areas; 3.7 – Late Successional Forest Landscape; 5.4 – Big Game Winter Range; and 5.1 – Resource Production Emphasis. The 3.7 – Late Successional Forest Landscape is within the unsuitable timber base as well as other designated old growth stands scattered through out the burn area. In addition, other portions of the burn area are unsuitable for timber production due to steep slopes, low productivity, low value tree species, and meadows. Approximately 35% of the area is unsuitable for timber production.

Post-Fire Conditions

Insects and Diseases



Wood borer residue

The insects that will most likely be infesting trees in the Battle Creek area can be broken into two classes, bark beetles and woodborers. Both have different feeding habits and will behave differently depending on the amount of fire damage on trees. In general, the probability that one or both of these insect groups will infest a fire-damaged tree increases with the amount of damage. It is also worthy of noting that populations of all of these beetles, red turpentine beetles, *Ips* beetles, which are both considered bark beetles, and wood borers, are at extremely elevated levels at this time. Storm breakage from 2 years ago led to population increases in these beetles and the other fire events the Black Hills has suffered over the past 2 years have caused beetle populations to increase even more. Insect infestations can play a big part in deciding whether the wood will be merchantable and whether salvage operations are warranted and how much time is available before infestations make the wood unusable.

Bark beetles

The most important bark beetle infesting ponderosa pine is the mountain pine beetle, *Dendroctonus ponderosae*. Mountain pine beetle has one generation per year, with its main flight and new attack period being early August. When populations of mountain pine beetle are high enough, they can attack and kill green, healthy trees. At low populations, mountain pine beetle typically attacks stressed or damaged trees, such as lightening struck trees. While it is true that mountain pine beetle does use stressed trees during low populations, it does not preferentially attacked fire damaged trees. This is in contrast to some of its close relatives such as Douglas-fir beetle. This does not mean that mountain pine beetle will not attack trees that are moderately scorched and have suitable phloem resources remaining. Generally speaking, fire damaged trees will NOT cause the start of a mountain pine beetle outbreak; however, mountain pine beetle could very well attack fire damaged trees if beetles are already present in the area.

The second most important bark beetle in the Black Hills are *Ips* species. There are a number of *Ips* species in the Black Hills that attack both pine and spruce. Fire scorched trees that still have some suitable phloem remaining are frequently attacked by *Ips*. Of all the insects that may be factors following the fire, *Ips* has the potential to build populations to a point where they can attack nearby stands of green timber. There is a very good chance that *Ips* will infest trees that are highly stressed from fire scorch. There is also a chance that surrounding green stands that did not receive any fire damage could have tree mortality caused by *Ips* if they build enough of a population in nearby fire damaged trees.

The third bark beetle that could be of importance is red turpentine beetle, *Dendroctonus valens*. Red turpentine beetle is found throughout the Black Hills attacking pine and occasionally spruce. Trees with fire damage may be attacked by red turpentine beetle. It is unlikely that red turpentine beetle will build to "epidemic" proportions that would be of concern to nearby standing green trees.

All three of the bark beetles introduce blue stain and other general fungi when the successfully attack trees. The blue stain fungi cause discoloration and other fungi that enter the beetle holes can start deterioration of the wood.

Woodborers

The other group of insects that typically follows fire events are woodborers. Woodborers are common residents of the Black Hills where they typically live in fire scorched, injured, dying and dead, and recently felled trees. Woodborers typically do not build up in fire-damaged trees and attack standing green trees, although there have been accounts of woodborers attacking highly stressed green trees. Generally they only attack heavily damaged or dead trees. The greatest concern with woodborers would be in areas that have been killed or heavily damaged by the fire where salvage logging is under consideration. Woodborers cause a much greater level of defect in lumber than do the bark beetles because they spend the bulk of their life tunneling through the heartwood of their host. Wood borers are plentiful in the Black Hills and will locate suitable material rapidly, so to minimize defect and degrade in fire damaged or killed areas, salvage operations should begin to take place as soon as possible following the fire to minimize defects caused by wood borers.

Effects

At this time we found all three of the major fire infesting beetles, red turpentine beetle, *Ips*, and woodborers, were infesting trees in the fire. In all cases, the attacks were very fresh and were in the stage of laying eggs under the bark. At this time, we did not find any larvae of any of the beetles that had hatched yet. Infestation levels were high in pockets, but in some places were fairly low and scattered.

The most often attacked trees were those that had been subject to the highest amount of fire scorch, either the all black or black with some brown needles remaining. At this time there is very little beetle activity in trees that had any unscorched, green crown remaining. Much of the findings in Battle Creek are opposite what has been observed in the Grizzly Gulch area, where beetle infestations were heavy on almost any fire-scorched tree, regardless of scorch level. This is largely due to the timing of the Battle Creek fire, in mid August as opposed to early July for Grizzly Gulch, which occurred when most of the significant flights were over or almost over.

This fire has provided another large amount of highly productive breeding material for all these beetles, which were already at elevated populations. Any of the fire damaged trees that remain next spring and summer will likely be subject to attack. Although trees that have only partial crown scorch will be the most resistant to attack, large existing beetle populations will increase their risk also.

Although beetles are just getting started in this area, any salvage operations should still occur very soon as beetles will be attracted to them this fall while they are still flying and in the spring again when beetle flight starts.

Vegetation Effects

The fire burned in a mosaic pattern with burn intensities of high, moderate, low, and unburned. Overall, within national forest lands, 2,496 acres (27%) of the Battle Creek Fire burned at high intensity, 4,742 acres (52%) at moderate intensity, 1,599 acres (18%) at low intensity, and 239 acres (3%) was unburned. High burn intensity areas in the ponderosa pine type killed nearly all of the pine in all size classes. Ninety to one hundred percent of the other species of trees, shrubs, forbs, and graminoids were killed as well as 70-90% of the loose litter layer. These areas experienced a stand-replacement fire, which set them back in their successional pathway to an early-seral stage.

Low burn intensity sites experienced relatively low tree mortality (0-20% for the pine vegetation type and less than 1% for other tree species). The bur oak and aspen within these areas were not affected and very little change in species composition and structure will be noticed. There may be a slight increase of growth in tree species, grasses and forbs due to the release of nutrients from the ground fire and reduction of litter and the competing duff layer.

Moderate burn intensity sites are highly variable. Tree mortality ranged from 10% up to 100%. The degree to which shrubs, herbaceous vegetation, and litter was killed or impacted on moderate intensity sites for all the vegetation types is highly variable and directly related to the fire intensity from individual tree torching, short duration crown runs, and the intense heat from the ground fuels consumed. Most of the moderate burn intensity stands experienced enough changes in structure to change their successional status to a grass-forb stage.

Throughout the fire area, even on sites that burned at high intensity, fine roots of trees, shrubs, forbs, and graminoids appeared to be intact (not burned) in the upper inch of mineral soil. This may be an indication that seeds in the mineral soil survived the fire and are available to germinate, grow, and establish cover on burn sites. Rhizomes of grass species also appear to have survived the fire and are expected to regenerate readily after fire.

Pine mortality will continue to occur in areas where greater than 60% of the crown was scorched. The cause of this mortality is insufficient crown mass to sustain biological tree functions; continued drought depriving trees of water; and insects.

Acres burned by vegetation type and burn intensity class

VEGETATION TYPE	HIGH INTENSITY	MODERATE INTENSITY	LOW INTENSITY	UNBURNED
Grass	42	300	179	29
Aspen	2	2	29	1
Ponderosa Pine	2,354	4,191	1,201	138
Bur Oak	98	225	161	38
Other Hardwoods	0	25	26	32

Vegetation Recovery

Bur oak and aspen are species that regenerate from root suckers following disturbance such as fire. Since these species are common on many sites throughout the burn area they will readily sprout and increase in numbers after being released from the pine overstory mortality. Overall, adequate natural vegetation recovery will occur in areas where either oak or aspen were present before the fire. In stands of pine where remnants of oak and/or aspen were scattered through out, mixed pine/oak and pine/aspen stands will appear. Over time the pine should crowd out the oak/aspen and predominantly pine stands will dominate the burn area.

Ponderosa pine is more limited in its response to fire. Unlike many deciduous trees and shrubs (aspen, oak), the root systems of conifers do not regenerate from root suckers. In order for a conifer to survive the fire, some of the roots, the cambium of the main trunk, the buds, and the live crown must survive. The best predictor of survival for the pine will be the amount of live foliage on the trees. In general, if at least one-third of the foliage is still green, and the cambium is alive, the tree should survive if drought and/or insects do not intervene.

Generally ponderosa pine seed can be expected to fall within 40 to 80 feet of the source. In large areas where the overstory pine was killed regeneration from adjacent pine will not be available. Ponderosa pine seed is viable for many years however, and within areas where the duff was not severely burned, residual pine seed may be available to regenerate some of the areas to pine. One of the greatest deterrents to successful regeneration and the establishment of ponderosa pine in the Black Hills is the presence of grass, especially sod forming grass. Grasses crowd out the pine seedlings restricting their growth due to competition for water and nutrients. Seeding for soil stabilization can also retard and in some cases prevent the natural regeneration process of ponderosa pine. Successful regeneration will also depend on moisture retention. Soils will dry faster where the canopy, litter, and down woody debris were consumed by the fire. This increases the potential for seedling mortality. Leaving down woody debris and slash on site will help retain soil moisture, reduce competition from grasses, and reduce soil temperatures by shading.

The success of naturally regenerating ponderosa pine is high. Past burns within the area indicate that while regeneration by natural means may be slow, regeneration does occur with an abundance of pine. Over a large area this can pose a future fire risk as "doghair" thickets of ponderosa pine are established and crown closure occurs.

Recovery of Commercial Timber

Timber Volume affected by the fire was calculated using satellite imagery and interpretation to establish the burn intensity within the various stands affected and calculating mortality volume and recoverable volume based on pre-burn forest inventory data. In some cases field observations and sale prescriptions were used to adjust predicted volume. Recovery of commercial volume both inside of timber sale areas and outside of sale areas is recommended.

Burn Intensity Class	Mortality Acres	Mortality Volume[1]	
		Sawtimber MBF	POL CCF
None	239	272	341
Low	1,599	3,084	3,641
Moderate	4,742	9,028	17,510
High	2,496	4,483	11,226

[1] *Mortality Volume is the total volume estimated killed within the Battle Creek Fire Perimeter on Black Hills National Forest Lands.*

Recovery within existing and planned sales

Timber Recovery should be considered throughout the fire area. For discussion purposes recovery has been divided as follows:

- Outside of planned and existing sale areas
- Within the cutting unit boundaries of the Beagle Timber Sale
- Within the sale area boundary of the Beagle Timber Sale and outside of cutting units
- Within the Bitter Sale and Hollow Sale boundaries (planned but not sold)

One timber sale is currently under contract and partially harvested. Two sales currently being prepared lie partially within the fire area. These are the Beagle (under contract), Hollow and Bitter Sales. The fire affected timber, both designated for removal and/or leave, harvest unit boundaries, and individually marked trees. Generally, trees within the areas of high intensity fire could be characterized as blackened from top to bottom. These areas sustained 100 percent mortality. Timber harvest unit boundaries and timber designation markings are non-existent within these areas.

Burned marked tree in existing timber sale

Trees within areas of moderate fire intensity have scorched (brown) foliage and blackened boles of varying heights. These areas sustained between 10 and 100 percent mortality. Timber harvest unit boundaries and timber designation marking are random and difficult to consistently locate. Some designation marks may only be visible on a small portion of the tree boles.

Trees within areas of low fire intensity have scorched (brown) foliage on less than 50 percent of the tree crowns and blackened boles generally less than six feet. Seedlings and saplings tended to sustain varying degrees of damage. Timber harvest unit boundaries and timber designation markings under areas of low intensity fire were generally retained. It appears that about 80 percent of the tree designations were retained. Marking designations most affected by the low intensity fire were stump marks.

Much of the burned area contains pine stands that consist of saplings, poles, and small sawtimber. The saplings and poles are likely to have no economic value in terms of timber recovery. Burned trees are generally not suitable for chip products. Areas of suitable recovery are spread out throughout the burn perimeter and may require additional transportation systems.

Timber value as a result of this fire has been reduced. The demand for fire killed timber is less than for green standing timber. Available time for harvesting these cutting units is limited if quality timber is to be recovered. Blue stain and insects will generally degrade the wood beyond use in less than one year. Insects of concern are longhorn beetles, red turpentine beetles, mountain pine beetle, and Ipps.

The following table summarizes the estimated recoverable volume affected by the fire within existing and planned timber sales:

Sale		Recovery Acres	Recovery Volume Sawtimber MBF	POL CCF
Beagle Existing	Inside CU's Not cut	140	600	900
	Inside CU's Cut	100	400	450
	Outside CU's	540	2,100	2,700
Bitter Planned		280	1,300	700
Hollow Planned		350	1,600	1,800

Recommendations

- Contract modifications should be made to recover value in commercial timber killed within the Beagle Timber Sale, both within existing cutting units and outside cutting units within the sale area boundary.
- The Hollow and Bitter sales should include areas burned within the planned sale areas and adjustments made to ensure regeneration and other resource needs are met.

- If not included in the Hollow and Bitter sales, recovery of commercial volume should be accomplished in a separate sale.
- Additional salvage sales should recover value in commercial timber outside of existing and planned green sales.
- Pine seed should be gathered to ensure quantities are available if future planting is necessary.
- Monitor seed cast from pine within the burn area.
- Retain green seed source trees within and adjacent to the burn area.
- Re-evaluate prescriptions for green units within the burn area.
- Monitor burned-over areas for natural regeneration.
- Some areas may need additional non-commercial trees felled to provide additional ground cover for seedling germination and protection from solarization.

Evaluation and Monitoring

The following monitoring should occur over the next 5-10 years within the burn area:

- Monitor seed cast and evaluate germination potential of pine seeds.
- Evaluate regeneration and stocking levels in the suitable land base.
- Plantability surveys to determine suitability and potential success of planting.
- Evaluate regeneration of aspen, bur oak, and pine stands.
- Continue evaluating pre-burn and post-burn stand conditions to determine future silvicultural treatments that would reduce the potential for large fire occurrence in this and other areas.
- Re-type the burn area and update the existing vegetation database to reflect changes created by the fire.
- Evaluate the suitability of sites within the burn area to determine whether they should be taken out of the suitable base and managed for other resources (i.e. wildlife or range).

Grass regrowth in the burn area

FIRE AND FUELS

Pre-fire Conditions

Weather, topography and fuels are the three primary factors that influence fire behavior. The Black Hills and surrounding areas are currently in a drought condition, as is much of the Western U.S. Two major fires had already occurred in the Black Hills earlier in the fire season, and overall conditions were exceptionally dry. Fortunately, some rain had fallen in the area prior to the Battle Creek Fire and this helped moderate the fire's effects somewhat. Temperatures were in the upper 80's and 90's three days prior to the fire with relative humidities in the teens. These conditions lowered the fuel moistures significantly and increased the Energy Release Component to the high level of 66. Weather conditions the day of the fire saw maximum temperatures in the high 90's with relative humidities as low as 8%. This coupled with wind speeds of 17-20 with gusts to 60 mph created explosive conditions.

Area topography added to the weather conditions. Steep sided canyons served to funnel strong winds and exposed ridgetops provided an avenue for rapidly advancing fire. Steep slopes along Silver Mountain and Boulder Hill provided conditions for the fire to move rapidly uphill.

The majority of the fire area consisted of dense stands of flammable ponderosa pine 60 years of age or older, with lesser amounts of more fire resistant aspen and oak. The timber canopy was largely continuous over most of the fire area, except for the eastern edge where the vegetation was more broken, consisting of open meadows intermixed with pine. This pattern of dense, unbroken stands of ponderosa pine is largely the result of past fire exclusion and timber management practices dating back 60 or more years. Storm damage from a snowstorm in the spring of 2000 contributed to the fire's intensities. Storm damage increased fuel loadings to 20-40 tons/acres in scattered patches throughout the area. These areas often provided the initial heat pulse that would move the fire from the ground to the crowns of the trees.

Post-fire Conditions

The fire burned in a mosaic pattern that was similar to that of a typical wind driven fire. A large percentage of the fire was intense enough to kill either the majority of trees in the stand or the entire stand. Most of the mortality occurred when the fire made runs on August 16th, 17th and 19th. Most of these runs were centered on ridge tops and steep slopes. Fire behavior was very intense with flame lengths over 100 feet and spotting up to one-half mile. The

Crown fire running

burning that occurred outside of the wind events usually consisted of a low to moderate intensity ground fire that killed only a small amount of the larger trees.

Preliminary reconnaissance indicates that the fire did not act as a thinning agent. The fire tended to kill the majority of the trees in the overstory or a small percentage of the trees. There were not many areas where the fire actually thinned out the stand other than killing some of the smaller regeneration. The fire tended to kill most of the trees in the dense stands of small pole timber that were precommercially thinned and the fuels scattered. Here, sufficient fuels remained on site to ignite and sustain a crown fire. Fire intensities were significantly lower in the meadows and hardwood stands. Even when hit with a crown fire, these areas either did not burn or they burned with a low intensity ground fire. In fact most the successful control efforts that were made in the Hayward and Neck Yoke areas occurred when the fire left the conifers and entered the larger openings.

The fire will have both short and long lasting effects upon the fuels in the fire area. In areas that experience high intensity fires, most the area will not have sufficient ground fuel to carry a fire in the short term. In areas with significant crown scorch there will be enough needle cast to carry a fire but fire intensities will be low because very low fuel loadings. Within 5 years there should be sufficient grasses and forbs established to carry a fire with estimated fuel loadings of 3 tons/acre and a fuel bed depth of 1-2 feet. The fire season will be split and will be susceptible to fires in the spring and fall when the grasses are cured. High live fuel moistures should limit fire activity in the summer unless there is not sufficient rainfall to support the vegetation. Fires in this fuel type are likely to spread quickly with rates of spread over 50 chains/hour and moderate fire intensities. Fuel conditions will improve in areas on the Battle Creek fire where the forest was under burned without killing the overstory. Here, the fire removed most of the downed woody debris and ladder fuels. There will not be enough fuel on the ground to carry a fire except in isolated patches for 1-2 years. Fuel loadings will gradually increase with the yearly needle cast. Fire intensities should be a reduced level for at least 15-20 years.

Fuel loadings in moderate and high intensity fire areas will begin to increase significantly in 5 to 10 years when the standing dead timber in the area begins to fall. Once this happens dead fuel loadings will increase to 20-60 tons/acre. Most of this will be material greater than 3 inches in diameter and generally will not contribute to rapid spread rates. Over time, however, as new dense stands of young pine trees begin the grow among the heavy fuel loads, new fire risks will emerge. At that time, in 15 to 20 years, a fire in this area will have the right mix of fuels—young pine and heavy fuel loading from dead trees—to both carry a rapidly moving and long duration fire. Such an event would significantly affect the area ecology by cooking and sterilizing the soil. Further, the increase in fuel loading from dead trees may have an impact on our ability to suppress wildfires. Large amounts of downed woody debris may limit our ability to access areas with engines and will significantly decrease line construction rates.

Most of the large runs occurred in areas with continuous tracts of forested lands. When the fire reached the larger openings, forces were often more successful in their control efforts. This fire has provided us with an opportunity to help break up the continuity of the forest by maintaining larger openings on strategic portions of the landscape. These areas will help provide natural fuelbreaks that will help reduce the potential of another large fire occurring in this area. Prescribed fire and/or mechanical treatments will be needed in 15-20 years in order to help maintain these openings.

Recommendations

- If roads and trails are obliterated or blocked by fallen timber, access for fire suppression equipment and personnel may be a significant factor in meeting containment efforts. Efforts to keep fires from spreading from the forest onto private lands or to contain fires originating on private lands may be compromised.

- There are potential fire hazards within the area that need to be addressed, especially adjacent to access roads and private property. As dead trees fall to the ground, fuel loadings will increase to 20-60 tons/acre. These large fuels will not increase rates of spread but they could increase the fire's intensity and duration. They could also impede access to the fire and impede fireline construction. Dead trees should be removed to reduce fuel loadings adjacent to the access roads and private property.

- Some of the openings created by the fire should be retained in order to break up the continuity of the forest and to provide future fuelbreaks. An evaluation needs to be conducted and a long term plan developed to determine if these fuelbreaks are desirable, their location, and how to maintain them.

- The fire effectively removed most of the ground fuels and the fire should act as an effective firebreak for 10-15 years. Fuels will gradually begin to accumulate in the stands that were underburned. Prescribed burning should be used at 15-20 year intervals to help prevent future build-up of fuel loadings.

Monitoring

An opportunity exists to monitor how rapidly fuels begin to accumulate in areas that were underburned. By monitoring the fuels we will have a better idea what the most effective interval would be for using prescribed fire for maintenance.

Threatened structure

We need to monitor the pine encroachment into the openings created by the fire. This will provide us with the information that is needed to determine what kind of management will be needed to maintain these openings.

Monitor the oak and other hardwoods to see how effective the fire was in expanding their range. Fire killing large numbers of the larger stems would be undesirable but expansion of these species would help provide natural fire breaks.